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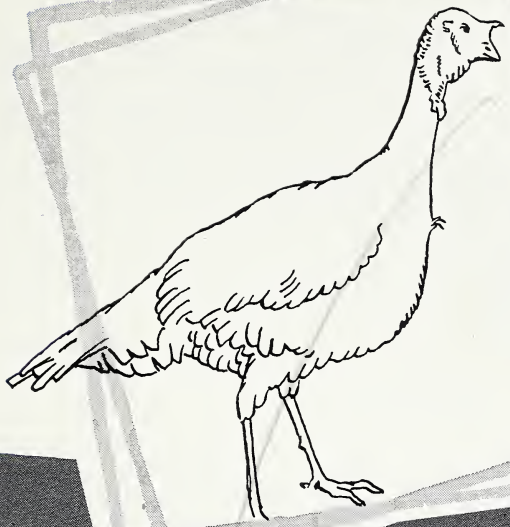

Carbon Dioxide Immobilization of Turkeys Before Slaughter

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C. FEBRUARY 1955

Summary

Tests to observe the effects of carbon dioxide gas on live turkeys, and to determine whether the gas could immobilize them effectively were made on a total of 475 Broad Breasted Bronze, White Holland, and Nebraskan variety toms and hens. Carbon dioxide gas at concentrations in the range of 10 to 95 percent caused characteristic and reproducible reactions in the birds. Overexposure caused death. Under conditions of the experimentation, practical limits were found to vary from 73- to 77-percent concentration with the optimum at 75 percent. Optimum time exposure intervals at 75-percent concentration were different for the different varieties and for the males and females within a variety. Within a variety and sex, the lightweight birds were more quickly immobilized than the heavier ones. Turkeys in their normal upright position were more quickly immobilized than those in an inverted or shackled position.

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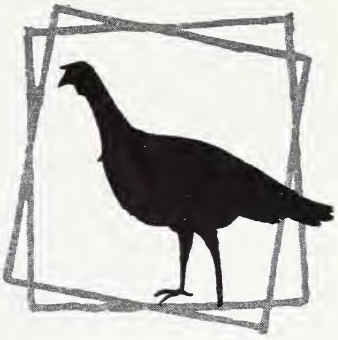

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Introduction

Loss of grade in processed turkeys is a serious economic concern of turkey processors. The reasons for this loss are many. Too often, the bruises, dislocated and broken bones, torn and abrased skin, and other defects are the direct result of the struggles of the large and excitable birds during removal from coops and during shackling, killing, and bleeding. Immobilization of the turkeys, if possible to accomplish before the birds are hung on shackles, or even before they are removed from the coops, should minimize the handling problems and decrease the number of downgraded carcasses.

At least four methods have been used with various degrees of success for immobilizing animals before slaughter. "Knocking," that is, stunning an animal by a blow to the head, has probably been the most widely used method for large animals. It has not been adapted to poultry processing, but Davis and Coe (*2*)[2] reported experimental work in which better bleeding was observed in poultry that had been knocked before the carotid arteries were severed than in poultry killed according to usual commercial practice. The method does not appear to be adaptable to immobilization of poultry before shackling.

Electric shocking has been widely used in Europe to immobilize large animals. Results of various studies of this method are reported by Müller (*5*, *6*), Anthony (*1*), and Hill (*4*). In this country electric shocking has become very popular, in the last few years, for immobilizing poultry, and especially turkeys.

[1] This report covers a part of the research, conducted under plant operating conditions by the Biological Sciences Branch of the Agricultural Marketing Service, for the solution of technical problems involving the processing of poultry. The work was carried on under authority of the Agricultural Marketing Act of 1946 (RMA, title II).

Appreciation is expressed for the cooperation of Maplecrest Turkey Farms, who supplied facilities and materials; the Barker Equipment Company for test equipment and technical assistance; the Pure Carbonic Company for test materials, and the Ranarex Division of the Permutit Corp. for loan of test instruments. Individual acknowledgment is due Allen Sharp of the Barker Equipment Company for advice and technical assistance on engineering problems and Dr. Edwin H. Matzen, of AMS, under whose supervision the work was initiated.

[2] Numbers in parentheses refer to literature cited page 9.

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It is usually applied just before the sticking operation. The method has not been adapted to before-shackling immobilization. Debraining, a stunning by destruction of the brain, has been used almost exclusively for poultry. Strictly speaking, it is part of the killing operation and does not lend itself to use before shackling.

Carbon dioxide immobilization has been reported by Swem (*7*), to be in successful use for immobilizing hogs. This method involves an exposure of the animals to a proper atmosphere of carbon dioxide gas. The animals become unconscious and are then easily handled. Reported advantages of the method are more complete bleeding, increased yields, reduction of labor costs, and elimination of noise, dirt, danger, and employee irritation.

Of the four methods, the carbon dioxide method appeared the most adaptable for "before the line" application in poultry processing plants. Apparently little or no work had been done on the effects of carbon dioxide gas on turkeys. However, one report by Hiestand and Randall (*3*) on species differentiation in the respiration of birds by carbon dioxide administration did consider domestic fowl. The present study was made to observe the effects of carbon dioxide on live turkeys and to determine whether turkeys could be immobilized by gas.

Equipment and materials

An experimental wooden airtight chamber, 2 feet wide, 4 feet deep, and 12 feet long, with doors at the top at both ends, was used for exposing the birds. A variable-speed conveyor ran the length of the inside of the chamber at a depth of 36 inches from the top. One side and both end panels had windows through which birds could be observed during exposure. Two electric lights illuminated the inside. The gas was fed into the chamber through three inlets at the top from standard carbon dioxide cylinders. An automatic recorder was used to measure the carbon dioxide concentration at a number of positions in the chamber. An electric fan inside the chamber circulated the air and gas and kept the mixture constant at all places.

Other equipment consisted of a spring scale on which birds were hung for weighing, a veterinarian's stethoscope for detecting heart pulsations, and stop watches graduated to $\frac{1}{10}$ second for timing the exposure.

Experimental procedure

The test chamber was set up in a commercial processing plant near the position at which birds were hung on shackles for slaughter. This placement allowed close adherence to commercial practices.

The turkeys for the tests were taken, as needed, from the same coops as were those for normal processing. No special selection was made, except that unhealthy or otherwise unrepresentative birds were excluded. A total of 475 toms and hens of the Broad Breasted Bronze, White Holland, and Nebraskan varieties were used in the tests. No attempt was made to determine their ages, nutritional status, previous environment, or other previous history.

Carbon dioxide gas was introduced into the chamber until the desired concentration was reached. The fan was allowed to mix the air and carbon dioxide for a few minutes before the bird was put into the chamber. This was repeated before each bird was put into the chamber. Initially, the 5-percent increments of gas concentration between 10 percent and 95 percent were tested. At each of the concen-

trations, a number of exposure times in the interval of 10 to 200 seconds were used. After the limits of effective concentrations were determined, 2-percent increments were tested.

When the concentration of carbon dioxide in the chamber was at the desired level, the conveyor was put in motion. One bird at a time was weighed and put through the chamber. The test bird was quickly inserted through the door at the end from which the conveyor traveled, and the door was shut immediately to prevent diffusion of the test mixture of air and carbon dioxide. Figure 1 shows a turkey being placed in the test chamber. The bird was always faced toward the direction of travel, as only in this position would it ride the conveyor. The bird was allowed to ride the conveyor to the terminal end, at which point the conveyor was stopped. Timing was started at the moment the turkey's head was beneath the door opening. The bird was removed from the chamber immediately after expiration of the desired exposure time and inspected for effectiveness of immobilization.

Effectiveness of immobilization was judged by movement, limpness, appearance of sleep, and heart pulsation. A bird was adjudged effectively immobilized when it displayed a complete lack of movement, closed eyes, limpness, and a detectable heart pulsation, throughout the time necessary for its passage through the shackling, sticking, bleeding, and dry feather pulling operations.

Results and Discussion

General Effects of Carbon Dioxide on Turkeys.—A number of reactions were observed in turkeys exposed to carbon dioxide gas. Generally and in the following sequence, they were: Shaking of the head, inability to stand, increased depth of breathing, dorsiflexion of the head, collapse, increased rate of heart pulsation, closure of the eyes, and unconsciousness. At some concentrations and exposure times there was also incidence of wing spasms, violence, and death. The

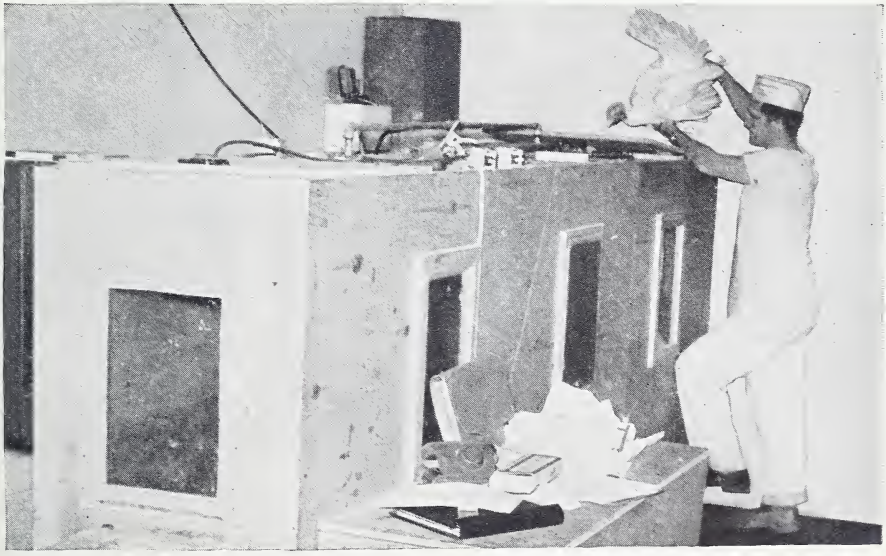

Figure 1.—Turkey being placed in the test chamber.

reactions occurred individually or in combinations, depending on the concentration and time of exposure. At most concentrations, the first six reactions appeared quite rapidly except that their appearance was slower at low concentrations than at high concentrations of gas. The appearance of the bird also changed; during the exposures the bird's head, wattles, and upper neck lost their characteristic red color and became a bluish white. One other reaction was observed during the bleeding of treated birds; the blood was a deep blue to purple color rather than a bright red.

A repeated shaking of the head as if to get rid of an irritant was the first noticeable reaction of birds in an atmosphere of 10- to 95-percent carbon dioxide. This appeared to be a simple nervous reaction to gas irritation of the naso-pharyngeal and tracheal regions. The irritation was probably a burning sensation similar to that experienced by the authors when they inhaled some of the heavy concentrations while they recovered unconscious birds from the chamber. With greater concentrations of gas, the reaction in the turkeys appeared more quickly and was more pronounced. At this state of exposure, as after longer exposure, there were few observed escape attempts at concentrations below 77 percent. Figure 2 shows a bird which has just begun to exhibit this reaction.

FIGURE 2.—Turkey exhibiting the first reaction to an atmosphere of carbon dioxide.

Loss of the ability to stand was the second reaction. The bird stumbled about and either sank slowly to a sitting position or dropped heavily to the conveyor. At low concentrations of gas, the reaction appeared more slowly than at high concentrations, at which the bird sat down heavily after 5 to 10 seconds. Figure 3 shows a turkey immediately after it had lost its ability to stand. The turkey had been exposed to a concentration of 75-percent carbon dioxide for about 10 seconds.

An increase in the depth of breathing, accompanied by a decrease in breathing rate, appeared quickly. The bird after short exposure breathed deeply in delayed gasps. Figure 4 shows a bird in the process of drawing a gasping breath.

FIGURE 3.—A turkey which has lost the ability to stand after exposure for approximately 10 seconds to a 75-percent concentration of carbon dioxide.

FIGURE 4.—Carbon dioxide effect on a turkey's breathing.

The next reaction was dorsiflexion of the head. The bird lost the ability to control its neck muscles so that after a slow wavering of the head, the head fell backward, or, as it often appeared, was drawn back onto the dorsal part of the body. At low concentrations a long exposure time was needed to cause dorsiflexion. The turkey in figure 5 shows dorsiflexion of the head. The bird also displays inability to stand and deep breathing.

FIGURE 5.—Turkey in which carbon dioxide has caused dorsiflexion of the head.

Collapse quickly followed dorsiflexion of the head. The bird usually rolled over onto its side, with its head resting on the conveyor. Figure 6 shows a turkey collapsing from carbon dioxide inhalation. It had not fully collapsed, as the head was still dorsiflexed.

FIGURE 6.—Turkey that has collapsed from inhaling carbon dioxide.

A great increase in the rate of heart pulsation in every exposed bird accompanied the above reactions. At times the pulsation was so rapid as to be barely detectable, and sometimes it was even momentarily undetectable. In both instances, when the bird was allowed to recover, the heart rate decreased to a natural rhythm.

Eye closure and complete collapse took place after relatively long exposure when concentrations were below 75-percent carbon dioxide, and after relatively short exposures when concentrations were above 77 percent. Eye closure alone was not always an indication of complete unconsciousness. Often birds that appeared unconscious opened their eyes when touched or moved. Unconscious birds, on the other hand, always had their eyes closed.

After a bird collapsed, closed its eyes, and lapsed into unconsciousness, its breathing became less noticeable. The gasping type of breathing lessened, the beak closed, air intake was through the nostrils, the breathing was not so deep, and the rate was more regular. A turkey in this condition is shown in figure 7. Sometimes the breathing was almost imperceptible. As long as a bird was alive, however, breathing action could be detected by watching the feathers and area surrounding the anus.

FIGURE 7.—A turkey with its eyes closed after it has lapsed into unconsciousness.

Violence or muscle spasms, or both, were noted in the reactions of some turkeys at concentrations above 77 percent. The first few inhalations of the heavy carbon dioxide atmosphere by the birds were usually enough to initiate a wild behavior. This was followed quickly by collapse and eye closure. The turkeys then suddenly became stiff and displayed muscular spasms which were most noticeable in the wings. The spasms lasted only a short time and were usually followed immediately by limpness and death. Because of this, 77 percent was considered to be the critical upper concentration under conditions of this experimentation. Death, without the violence and muscular spasms, was frequently a rapid occurrence in birds exposed to low concentrations also. When excessively long exposures were needed at low concentrations to render the birds unconscious, a high percentage of them died quickly after losing consciousness.

These findings gave the authors considerable difficulty in establishing the fact that turkeys could be immobilized by carbon dioxide without death occurring so quickly after exposure that the immobilization would be commercially useless. It was understood that those working with hogs did not have the same difficulty. Later it was seen that the difficulty arose because the optimum immobilizing effect of carbon dioxide in turkeys was restricted to rather narrow concentration ranges and exposure time intervals. Differences in the respiratory mechanisms of hogs and turkeys may be responsible for the different effects of the gas.

The air sacs and hollow bones in turkeys may interfere with the immobilizing action of the carbon dioxide initially and with the recovery of the bird after immobilization. At concentrations below 73 percent, the birds seemed able to resist unconsciousness for a considerable time. Such a delaying action may have been caused by residual oxygen in the bones and air sacs. Conversely, recovery of consciousness by the immobilized birds appeared to be delayed to the extent that some birds never recovered. It appeared that in this case residual carbon dioxide in the bones and air sacs affected the recovery.

In the effective ranges, the concentrations of gas were evidently great enough to balance and overcome the effect of the residual oxygen and cause immobilization without being so great as to cause death.

IMMOBILIZING EFFECTIVENESS OF CARBON DIOXIDE.—Carbon dioxide gas was found effective for immobilizing test turkeys. It was found possible to render them unconscious and have them remain so without dying throughout the shackling, sticking, and other operations preceding scalding, until they died of loss of blood. Certain requirements in the method of exposure were necessary, however, for obtaining the desired results. Simple exposure of birds to the gas was not successful. Instead, proper combinations of gas concentrations and time of exposure had to be determined and utilized. It should be noted that the concentrations and exposure times determined for the test birds in this experiment will not necessarily be the proper com-

binations for use in all places and on all turkeys.

Under the conditions of this experiment, concentrations ranging between 73- and 77-percent carbon dioxide were found to immobilize the test turkeys effectively. Concentrations outside this range did not give dependable results. Figure 8 shows an immobilized turkey immediately after it was removed from a 75-percent atmosphere of carbon dioxide.

FIGURE 8.—A successfully immobilized turkey.

Within the range of 73- to 77-percent carbon dioxide concentration, a number of effective exposure times were found to exist for any one sex and variety. The limits of these effective exposure times when expressed graphically formed an "interval" of optimum times. Thus, every bird of a given sex and variety was successfully immobilized when it was exposed for any one of the times within the interval of optimum exposure times for that particular sex and variety. A different interval was found to exist for each of the varieties tested as well as for the sexes. The exposure time intervals determined at the 75-percent concentration are shown graphically in figure 9. The intervals at this concentration were selected for graphing because consideration was given to possible commercial application which would require sufficient time flexibility for coordination of mechanical operations. The six intervals at 75 percent were greater than they would be at any other concentration and therefore satisfied commercial requirements best.

In the determination of the lower limit of the optimum exposure interval for a particular sex and variety, weight had to be considered. It was found that lightweight birds of one variety and sex could be immobilized at lesser exposure times than those necessary for heavier birds of the same variety and sex. However, because reproducibility of result is a necessary requirement of commercial methods, the intervals shown in figure 9 were cut off to include only the exposure times at which every bird, regardless of weight, was successfully immobilized. Weight did not appear to make a difference between breeds. Thus, even though some of the Nebraskan toms were heavier than some of the Broad Breasted toms, the Nebraskan toms did not require as long an exposure for immobilization.

Another factor which affected the exposure time requirement was the position of the birds during exposure. Turkeys suspended by their feet with head down needed more time for immobilization than

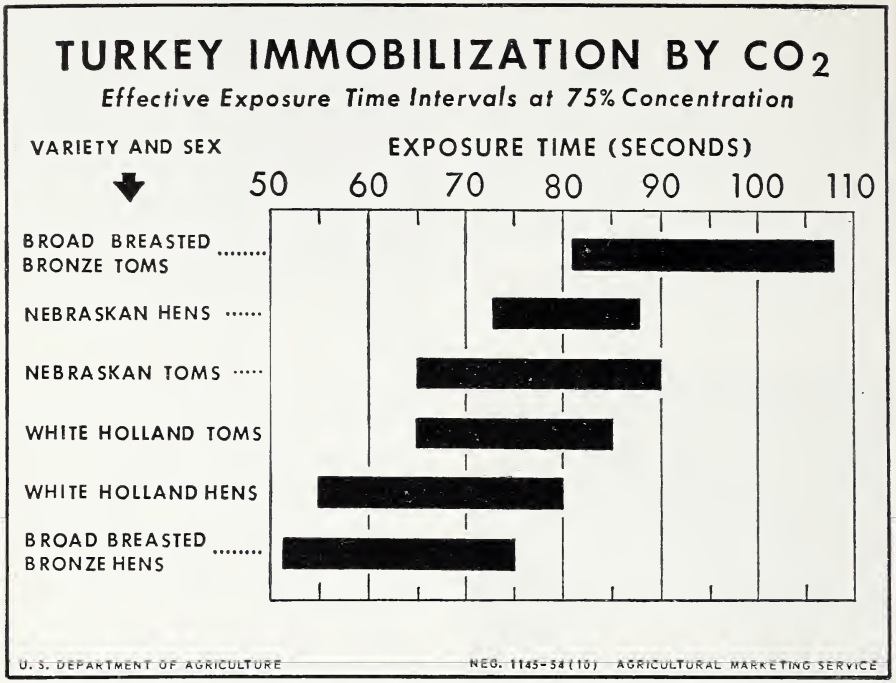

FIGURE 9.—Intervals of exposure time during which turkeys of different varieties and sexes were successfully immobilized when concentration of carbon dioxide was 75 percent.

birds exposed in their natural upright position.

Every turkey was carefully inspected after evisceration for detrimental effects resulting from the treatment. No defective birds were found.

Statements have been made earlier concerning the probability that concentrations and times found to be critical under conditions of this experiment may not necessarily be critical in other places and on other birds. Turkeys are raised and processed in many different places and under different conditions. Temperature, method of handling live birds in transit to the plant, condition of the turkeys, strain of a variety, and other variables may very well affect the physiological condition in which the birds reach the immobilizing chamber. For these reasons it is wise to point out that while the reactions should be the same, the concentrations and times of exposure at which they occur may differ in different places.

Conclusions

Carbon dioxide causes reactions in turkeys which can be described as characteristic of such birds exposed to the gas. The reactions can be reproduced. Turkeys can be immobilized effectively with carbon dioxide when proper combinations of gas concentration and exposure time are used.

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